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ASSESSING THE RELATIONSHIP BETWEEN SURFACE AND SHALLOW GROUNDWATER FLOW SYSTEMS AND RIPARIN VEGETATION AND SOILS

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PROJECT SUMMARY

This proposed research project is part of a comprehensive study of relationships among geomorphology, hydrology, and vegetation in central Nevada riparian ecosystems. The comprehensive project aims to determine the instream flows required to maintain and restore riparian ecosystem structure and function. Within the context of the comprehensive project, we will determine the how gradients in depth to groundwater and riparian vegetation and soils interrelate. We will examine these relationships within two distinct geomorphic positions in two separate drainages. We will also attempt to select indicator species which indicate favorable conditions of stream flow and changes in stream flows for each geomorphic position. The above results will be related to those of the geomorphology and hydrology analyses to gain a better understanding of riparian ecosystem processes. This compilation of knowledge will be used to create predictive models which define the instream flows required to support riparian ecosystem integrity. Such predictive ability is necessary when assessing the potential impacts of land uses and management strategies.

STUDY AREA

The study area is in central Nevada, specifically Big Creek in the Toiyabe mountain range and Corral Canyon in the Toquima mountain range. Within each drainage, sites that represent riparian ecosystems typical of the Great Basin were selected. Big Creek is grazed by sheep and Corral Canyon by cattle for designated periods in the growing season. Basins in the Toiyabe and Toquima mountain ranges are semi-arid and typically receive less than 25 cm of precipitation per year, primarily in the form of snow (Weixelman et al. 1996). Perennial, ephemeral, and intermittent streams exist throughout central Nevada; however, for the study at hand we have limited research to sites with perennial streamflow. The majority of streams in these mountain ranges have narrow channels and have been subjected to incision (Weixelman et al. 1997). Stream incision may cause adjacent groundwater tables to lower which could, in turn, affect species composition and abundance of the vegetation (Smith et al. 1991).

MODEL SYSTEM

In central Nevada, geomorphology strongly influences the characteristics of different stream reaches and consequently, the vegetation. Alluvial fans, or other geomorphic features such as faults, block downvalley subsurface flows and result in locally elevated water tables within the riparian area. These areas are classified as gaining reaches and often have a wide riparian zone. Upstream of alluvial fans stream gradients increase and subsurface flows are unobstructed allowing for water to flow from the stream to the adjacent land. These areas are classified as losing reaches and consist of a narrow riparian zone.

Within Big Creek and Corral Canyon alluvial fans are present. These geomorphic features influence the soils, vegetation, and subsurface hydrology of each site. Past or present depositional areas lie immediately upstream of the alluvial fans and are characterized by low gradients. These areas are often characterized by finer textured soils (Chambers et al. in press). Farther upstream lie higher gradient areas often characterized by coarse sediments. It is necessary to understand how stream reaches in both geomorphic positions function to accurately characterize instream flow requirements.

Geomorphic position can affect the composition and distribution of the riparian vegetation. Immediately upstream of alluvial fans meadow complexes exist along a hydrologic gradient. Species located along the hydrologic gradient from wet to dry conditions include the *Carex nebrascensis* ecosystem

type, mesic meadow type, and dry meadow type (Weixelman 1996). Along this soil water gradient each species may exist under particular conditions; specifically, within a certain water table regime. Examples of such possible indicator species include *Carex nebrascensis* dominating areas with fine textured soils and where the water table is saturated at a depth of 0-30 cm (J. Chambers unpub.), *Carex angustata* dominating areas where the water table is within 55 cm from the surface (Allen-Diaz 1991), and *Deschampsia caespitosa* dominating areas where the water table drops below 70 cm (Allen-Diaz 1991). Farther upstream willow complexes exist and are characterized by willow and understory species. Species composition is comprised of perennials and annuals and varies within meadow and willow complexes as the two succeed toward later seral stages. Changes in species composition are influenced by several factors such as climate, disturbance regime, community interactions, and life history characteristics (MacMahon 1980).

Within gaining and losing reaches, water table gradients are strongly evident. Immediately upstream of alluvial fans, riparian vegetation experiences expansive elevated water tables. Farther upstream, reaches are characterized by steep gradients and water tables that decrease rapidly with distance from the stream. It appears as though hydrologic gradients in these areas are closely related to the local geomorphology and subsurface flows. For this study, we will sample two geomorphic positions in Big Creek and one in Corral Canyon drainages for a total of three sites.

OBJECTIVES

The objectives of the comprehensive study are (1) To determine the relationships between geomorphic features, instream flow and groundwater hydrology, and riparian vegetation and soils in central Nevada riparian ecosystems and (2) To construct a model based on these relationships and to make accurate predictions of the instream flows required to support riparian ecosystem structure and function. Together, Jerry Miller (Indiana University-Purdue University of Indianapolis, hereafter referred to as IUPUI), Karen Farleigh (IUPUI), Dave Jewett (Environmental Protection Agency), Dee Richards (IUPUI), Jeanne Chambers, Sherm Swanson, and Regine Castelli (University of Nevada Reno) will document the relationships existing within riparian ecosystems.

The objectives of the vegetation-groundwater study are (1) To determine the relationship between the spatial and temporal hydrologic gradients and the soils and vegetation within each site, (2) To examine the differences in these relationships for the two distinct geomorphic positions within the riparian corridor, and (3) To determine if indicator species can be selected that indicate favorable conditions of streamflow for the different geomorphic positions (i.e., gaining and losing reaches). The following questions are asked:

1. How do relationships between the hydrologic gradients and the soils and vegetation change through time and space within and between sites?
2. Does geomorphic position influence the temporal variability of the hydrologic regime and consequently, the soil and vegetation relationships?
3. Can species be selected that consistently indicate similar hydrologic conditions within and between geomorphic positions?
    a. Are the ranges in water tables over which species occur sufficiently narrow to reliably indicate instream flow requirements?

METHODS

The following is a brief outline detailing the parameters used to characterize the geomorphology, hydrology, vegetation, and soils of the two study sites.

Geomorphic Features: J. Miller and K. Farleigh are documenting the channel form and depth to entrenchment with respect to side-valley alluvial fans. They are measuring cross-sectional areas of the stream channels, completing pebble counts at multiple locations within each stream, and describing the stratigraphy of the alluvial fans. Furthermore, they are determining the factors controlling channel entrenchment through the analysis of axial and alluvial fan deposits within the study areas.

Instream Flow and Groundwater Hydrology: D. Jewett and D. Richards are determining water sources at the study sites. They will create a sediment transport model to predict minimum flow required to carry sediment and maintain the current channel morphology. Additionally, Jewett and Richards are characterizing the shallow groundwater in terms of flow direction, hydraulic gradient, and flow velocities. This is used to determine the factors controlling the nature of the shallow groundwater flow system. With

the hydrologic data, a model will be created to predict the effects of stream downcutting on water table levels in the adjacent areas.

Riparian Vegetation and Soils: J. Chambers, S. Swanson, and R. Castelli will document the relationships between the surface and shallow groundwater flow systems and the riparian vegetation and soils. This will be done by examining species composition and abundance of riparian vegetation in the greater riparian areas and various soil and environmental variables (depth to groundwater, valley slope, rooting depth, soil oxidation-reduction potential, soil moisture content, depth to saturation, and soil temperature). Both the spatial and temporal aspects of depth to groundwater are highly influential on vegetation (Halpern 1986, Allen-Diaz 1991) and it will be intensively sampled; the remaining variables will be sampled at a lesser intensity. After these data have been collected, we will determine how the gradients in depth to groundwater relate to both the gradients in the vegetation and the other variables within and between sites over time.

***Study Design*:** Study sites for this project were chosen in June 1997. Within each of the two drainages, study sites were selected that represent each geomorphic position.

Groundwater sampling: Within each study site approximately 50 piezometers were located throughout the greater riparian area. Piezometers were installed to monitor groundwater levels and are located along transects perpendicular to the stream at subjective intervals corresponding to changes in the vegetation (Halpern 1986). By monitoring the water table levels, we will be able to determine the hydrologic gradients within each geomorphic position. Transects were placed throughout the entirety of each site and include all vegetation types existing within each site. Piezometers were installed about 20 cm below the current water table or, if the water table was not reached, until the piezometer could be driven no deeper due to rocky substrate (approximately 6 m). In some instances it was necessary to install slotted PVC wells to verify piezometer readings. Depth to groundwater was monitored using a groundwater level seeker. Measurements were taken semi-weekly and after precipitation events throughout the growing season (July and August) and monthly during the remainder of the year when the sites were accessible in 1997. This is fundamental in determining the temporal influence groundwater has on the vegetation and soils. The elevations corresponding to each piezometer were documented using a TOTAL station (N = 50 per drainage). In doing so, the valley slope for each site was determined.

***Vegetation Sampling*:** The vegetation of study sites will be sampled in July 1998. To obtain the necessary vegetation data, we will sample areas immediately surrounding the piezometers. We will use three 0.1 m x 0.1 m plots at 120^{o} angles from each other and 20 cm from the piezometer. In the sagebrush dominated areas, three 1 m x 1 m plots will be substituted for the 0.1 m x 0.1 m plots. This will provide an accurate account of the sagebrush density. Three plots will be used to ensure adequate representation of the vegetation (50 piezometers x 2 drainages x 3 plots = 300 plots). We will document the species composition and abundance using nested frequency techniques. In addition, we will use one point frame per plot to characterize the ground cover according to the basal vegetation, litter, bareground, gravel, rock, or dung. Species composition, abundance, and ground cover will be sampled within the same plot. We will average the species composition and abundance values of the three plots to establish one set of values per area surrounding each piezometer. Ground cover composition will be transformed to percent covers and averaged between the three plots. Vegetation sampling will occur for two weeks in mid-July of 1998. At this point in the growing season most plants will be in flower thus permitting expedient identification. Additionally, this sampling period is prior to sheep and cattle grazing activities.

***Soil Sampling*:** Riparian soils influence vegetation patterns (Ratliff and Harding 1993) and are affected by the hydrologic and depositional gradients and biology of their specific system (Brown et al. 1978). In order to quantify the differences in soil characteristics, we will utilize a variety of parameters to characterize the soils including rooting depth, oxidation-reduction potential, soil moisture content, depth to saturation, and soil temperature.

We will dig soil pits to characterize the soil profiles and determine the soil types. Soil pits will be dug once in July 1998 and spaced subjectively to incorporate all possible vegetation types and hydrologic conditions; the exact number will depend on the number of vegetation types and the hydrologic gradients present (approximately N = 1 per vegetation type, or four per site). Two additional soil cores per vegetation type will be taken throughout each site to insure that soil pits are representative. In the process of characterizing the soil pits, we will determine the rooting depth. Rooting depths and abundance are believed to represent the condition of a site (Weaver 1919 in Weixelman et al. 1996). For example, a short rooting depth may indicate compaction of the soil. Rooting depths can be determined by taking soil cores and recording root size, abundance, and location (Soil Survey Staff 1993).

In addition to the recording rooting depths, we will take samples from each soil pit and augered hole to quantify soil water contents in lab. This totals three replicates per horizon per vegetation type (1 soil pit, 2 augered holes) for each site. The relationship between soil water content and soil water potential can be displayed using a soil moisture release curve (Rundell and Jarrell 1989). Release curves vary depending on soil texture (i.e., clay content, organic matter content) and structure (Klute 1986). Weixelman et al. (1996) found *Carex nebrascensis* to occur in fine-sandy textured soils, dry graminoid species to occur in fine-loamy textured soils, and warm willow mesic graminoid species to occur in gravelly textured soils with episodic deposits of coarse and fine textured materials. In constructing a soil moisture release curve, soil samples are saturated to a specific water potential followed by the application of a fixed pressure. Water content can be determined after the soil sample no longer releases water and has reached an equilibrium. I will sample approximately 100 g of soil for each replicate at the O, A, and B horizons when present. Samples will be sieved in lab to remove coarse fragments prior to the application of fixed pressure. Soil moisture release curves will be constructed using water potentials of 0.3 and 1.5 Mpa. Methods by Klute (1986) will be followed to determine the soil water potential.

Beginning in June 1998, redox potentials, soil moisture content, depth to saturation, and soil temperature will be sampled within a 50 cm radius of piezometers. Subsequent monitoring will occur at three week intervals through September 1998. Within each vegetation type, five replicates will be instrumented at 30 cm depths. Instruments will be installed within a 50cm radius of the piezometer. For the *Carex nebrascensis*, mesic meadow, and warm willow vegetation types, an additional set of instruments will be installed at 20 cm depths for three of the five replicates. The additional instruments will help to define the vertical gradients. The instruments placed at 20cm depths will be identified using orange label tape.

Soil oxidation-reduction (redox) potentials indicate electron availability (Faulkner et al. 1989) and degree of biological activity (Pearcy et al. 1989). We will measure redox potentials following methods outlined by Faulkner et al. (1989) and Mueller, Stolzy, and Fick (1985). This involves placing platinum electrodes into the soil and taking measurements using a Ag/AgCl reference electrode and portable voltmeter. Platinum electrodes will be constructed by soldering a 1.3 cm long piece of 22 gauge platinum wire to a 42 cm long 3.9mm diameter copper rod. The solder is sealed with AquaSeal neoprene glue.

Next, the copper rod is covered with heat shrink tubing. Salt bridges act to improve conductivity in dry soils. Salt bridges will be constructed according to methods outlined by Veneman and Pickering (1983). A 7.5 cm long 1.9 cm diameter PVC piece is joined to a 35 cm long 1.25 cm diameter PVC pipe using a coupler and bushling. Approximately 2.5 cm from the bottom of the pipe, a 6 mm diameter hole is drilled and covered with label tape. A PVC cap is glued to the bottom end of the pipe. Next, a solution of KCl and cell culture tested agar is brought to a boil. Upon cooling slightly, a few grains of loose phenol crystals are added. The solution is then poured into each PVC pipe and allowed to gel.

In the field, platinum electrodes and salt bridges will be placed within 10 cm of each other. To install the platinum electrodes, range pins are placed approximately 18-19 cm and 28-29 cm deep in the soil and then removed. In the hole created, a platinum electrode will be inserted. The electrode is then gently pushed an additional 1-2 cm deeper into the soil. This ensures that the platinum wire is in full contact with the surrounding soil. Electrodes will be given 7 days to equilibrate before the first measurement is taken using a Ag/AgCl double junction reference electrode and portable voltmeter. Prior to installation of each salt bridge, label tape covering the drilled hole is removed. A hole will be bore into the soil at depths of 25 and 35 cm using a screw auger. Salt bridges will be inserted into the holes so that the drilled opening is level with the platinum electrode. The hole is then back filled with soil removed during the installation process. Throughout the growing season, de-ionized water will be added to the salt bridges maintain their gel-like status if evaporation has taken place.

Ratliff and Harding (1993) believe soil moisture content controls plant distributions when all other physical factors are met. We will evaluate soil moisture content by sampling 50 ml soil cores at 0-10 cm, 25-35 cm, and 55-65 cm depths using a screw auger, transporting samples to UNR, and drying them at 105 ^{o}C for 24 hours (N = 3 depths x 20 per site x 4 sites = 240) (Faulkner et al. 1989). Wet and dry weights will be compared to determine gravimetric soil water content. In the process of sampling soil cores, we will observe and record the depth at which the soil is saturated. This depth is identified by a shiny, moist soil appearance. If depth to saturation is not reached by 65 cm, the no value will be recorded.

Soil temperatures can affect the distribution of species due to the biological mechanisms occurring at particular temperatures (Ratliff and Harding 1993). We will sample the soil temperature at depths of 20 cm and 30 cm using thermocouples to determine temperature regime. Thermocouples will be constructed

by cutting copper-constanten wire into 60 cm lengths. At both ends, approximately 2 cm of the wires will be stripped. Wires at one end will be soldered together using a solder iron and lead free rosin core solder. At the remaining end, wires will be secured into a copper-constanten mini-thermocouple connector. The connector allows for quick and precise connection to the thermocouple thermometer. Thermocouple accuracy will be verified in lab prior to field installation. Using a screw auger, a hole 20 cm or 30 cm deep will be bored into the soil. One thermocouple will be inserted into each hole which is then back filled with the extracted soil. Care will be taken to ensure the wire does not bend upon installation and that the entire hole is filled with soil. The excess length of thermocouple wire and the mini-connector will be left exposed at the soil surface. Thermocouples will be given seven days to equilibrate prior to the initial measurement using a type TC thermocouple thermometer.

Redox potentials and soil temperatures will be used to calculate the number of degree-days of anaerobiosis. Degree-days are calculated by the following formula (J. Qualls pers. comm.):

# of day since anaerobiosis*(temperature°C-4°C)

To ensure no damage is inflicted upon the vegetation, we will complete soil sampling in areas other than the three designated 0.1 m x 0.1 m and 1 m x 1m plots to be used for the vegetation sampling. Redox potential, soil moisture content, depth to saturation, and soil temperature will be sampled within two days of each other every three week period throughout June, July, August, September and October. These periods correspond to spring high flows, summer low flows, and fall recharge.

RELEVANCE

This proposed study is fundamental in determining the relationships between surface and shallow groundwater flow systems and riparian vegetation and soils in central Nevada riparian ecosystems. It will define how the environmental gradients, specifically depth to groundwater, interact with the vegetation gradients within two distinct geomorphic positions. It will also determine if indicator species can be selected that indicate favorable conditions of streamflow and changes in streamflow related to stream incision and water table lowering. Results of this study may be compared with those collected by the USFS Humboldt-Toiyabe Ecology Team which classified meadow and willow ecosystems in central Nevada. Through comparison, potential regional patterns should be evident. For instance, if soil classifications

completed in this study are similar to those of the USFS Humboldt-Toiyabe Ecology Team classifications, relationships between hydrology and vegetation found in this study can be applied over a wider region.

Results of the vegetation-groundwater study will be incorporated with those of the comprehensive project and will aid in increasing basic knowledge of the interactions occurring among geomorphology, hydrology, and vegetation within riparian areas. Perhaps most importantly, this cross-disciplinary investigation will serve to construct predictive models which indicate the instream flows required to maintain and restore the structure and function of central Nevada riparian ecosystems. For instance, one may predict how stream incision will affect instream flow depth, and thereby ground water levels, which in turn will affect the species composition and abundance of riparian vegetation. Subsequent changes in vegetation may alter wildlife habitat or water quality. Predictions based on this study will undoubtedly function to determine the potential impacts of changes in instream flow due to altered land uses and management strategies for central Nevada riparian areas.

RESEARCH SCHEDULE

1997	June	Select study sites Install piezometers
	July-August	Measure piezometers biweekly
	September-December	Measure piezometers monthly
1998	January-June	Measure piezometers monthly Install platinum electrodes for redox measurements and thermocouples for temperature measurements.
	June-August	Measure piezometers biweekly
	June 1-5	Soil sampling
	June30-July1	Soil sampling
	July 20-24	Vegetation sampling
	July 21-22	Soil sampling
	August11-12	Soil sampling
	September-December	Measure piezometers monthly
	September 1-2	Soil sampling
	September 22-23	Soil sampling
	October-December	Data entry and analyses
1999	January-May	Final report
	June	Submit manuscripts for publication

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